# Long-Term Survival Is Superior After Resection for Cancer in High-Volume Centers

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**Background:** A number of studies have demonstrated that surgical resection at high-volume centers is associated with improved short-term perioperative outcome. Whether long-term results after resection of visceral malignancies are superior at high-volume centers is largely unknown.

**Methods:** All patients who were subjected to pancreatectomy or hepatectomy for cancer in the years 1995 and 1996 were identified in the National Medicare database. Data extracted and examined include demographics, comorbidities, and long-term survival. All survival was confirmed through 2001, providing actual 5-year survival. Long-term survival was examined as related to hospital volume.

**Results:** In the study period, there were 2592 pancreatectomies and 3734 hepatectomies performed at 1101 and 1284 institutions, respectively. High-volume center was defined as >25 cases/y. By this definition, there were 10 high-volume centers for pancreatectomy and 12 centers for hepatectomy performing 11% (n = 291) of the pancreatectomies and 12% (n = 474) of the hepatectomies in this study period. Comparison by log-rank demonstrated superior survival for patients resected at high-volume centers (pancreatectomy: $P = 0.001$; hepatectomy: $P = 0.02$). This was confirmed by multivariate analysis. All analyses included an adjustment for within-center correlation.

**Conclusion:** Superior long-term survival is associated with complex visceral resections for cancer at high-volume centers.

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The last 3 decades have seen remarkable advances in hepatic and pancreatic surgery. Major liver and pancreatic operations are no longer unusual procedures, but are now commonly performed at many hospitals worldwide. These procedures have proven to be effective therapy for many benign and malignant diseases,[1,2] and have prolonged and improved the lives of many patients. These procedures that once were thought to carry prohibitive morbidity and mortality are now accepted as safe and effective therapy, and the only curative therapy for malignancies involving the liver[3,4] or pancreas.[3,5,6]

In recent years, data is also accumulating suggesting that the perioperative results of pancreaticoduodenectomy[7–9] or hepatic resections[9–11] are related to the volume of such procedures performed at a particular hospital. These are part of a growing literature suggesting that certain operative procedures should be regionalized, with the goal of concentrating such procedures at high-volume centers to improve perioperative outcome.[12–18] In relation to major procedures for cancer, it is largely unknown whether long-term survival after these operations may be altered by such regionalization. The aim of the current study is to examine the relationship between hospital volume with long-term survival in patients with cancer subjected to pancreatectomy or hepatectomy using a national database.

## METHODS

To evaluate the effect of hospital volume on long-term survival of patients subjected to complex surgical procedures for cancer, all patients who were subjected to pancreatectomy or hepatectomy in the years 1995 and 1996 were identified in the National Medicare database. Only pancreatic resections for adenocarcinomas and liver resections for cancer were included in this study. In the study period, there were 2592 pancreatectomies and 3734 hepatectomies performed at 1101 and 1284 institutions, respectively. In this period, 1062 liver resections (28%) were performed for primary malignancies of the liver and biliary tree, whereas 2672 resections (72%) were performed for metastatic disease to the liver.

### Definition of High-Volume Center

High-volume center was defined as >25 cases. The cases taken into account for consideration of institutional volume included surgery for benign disease, although the data analyzed for outcome in this paper included only cancers. By this definition, there were 10 high-volume centers for pancreatectomy and 12 centers for hepatectomy performing 11% (n = 291) of the pancreatectomies and 12% (n = 474) of the hepatectomies in this study period.

### Definition of Comorbidities

Data extracted and examined include demographics, comorbidities, and long-term survival. In the analysis for comorbidities, the following International Classification of

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Diseases, 9th Revision diagnosis codes were used: diabetes (250.x), essential hypertension (401.x), pulmonary disease (491.x, 492.x, 493.x, 495.x, 507.x, 511.x, 514.x, 518.x), renal disease (584.x, 591.x, 593.x, 596.x), and cardiac disease (396.x, 402.x, 410.x, 412.x, 413.x, 414.x, 415.x, 424.x, 426.x, 427.x, 428.x, 429.x). All survival was confirmed through 2001, providing actual 5-year survival. Long-term survival was examined as related to hospital volume.

## Analysis

Chi-squared and Student *t* test, for nominal and continuous, were used to evaluate the association of independent variables to hospital volume (low/high). In the analysis of comorbidities, chi-squared trend tests were used instead of standard chi-squared tests because we know that these data are ordered by complexity as the number of comorbidities increase.

All deaths within 30 days of surgery were considered surgical mortality. For univariate survival analysis, survival plots were by Kaplan-Meier and comparisons by log-rank. Analysis of survival was performed both for survival for the entire group as well as for those patients who survived the perioperative period. Multivariate analysis was performed to adjust for potential confounding factors using multiple linear regression models. Proportional hazards analysis was performed on all variables found significant by univariate analysis. Relative risk (RR) with 95% confidence intervals was calculated as a measure of association. All comparisons used a marginal model to account for within-center correlation[19] using the method of Wei et al.[20] Differences of $P < 0.05$ were considered significant. Statistical analysis was performed using JMP software (JMP; SAS Institute Inc., Cary, NC) and R (http://www.r-project.org).

# RESULTS

## Demographics

The demographics of the study populations are tabulated in Tables 1 and 2. A total of 2592 Medicare patients were subjected to pancreatectomies for cancer at 1101 hospitals in this 2-year period. The mean age of the patients was 72 years. Forty-seven percent of the patients were male. Comorbidities were found in 70% of the patients. As for the patients subjected to hepatectomies, 3734 resections were performed in 1284 hospitals. The mean age was also 72 years. Fifty-one percent of the patients were male. Sixty-six percent of the patients had comorbidities.

The demographics for patients treat at high- or low-volume centers are very similar. Thus, the improved outcomes seen at high-volume centers cannot be merely the result of patient selection. For pancreatectomies, there was a slightly higher proportion of pancreaticoduodentomies than at low-volume centers (86% vs 80%, $P = 0.03$). There was also a higher incidence of patients with hypertension (33% vs

**TABLE 1.** Demographics of Patients Subjected to Pancreatic Resection for Cancer

| | Total | Low Volume | High Volume | *P* |
|---|---|---|---|---|
| No. of patients | 2592 | 2301 | 291 | |
| No. of hospitals | 1101 | 1091 | 10 | |
| Age: mean ± standard deviation | 72 ± 6 | 72 ± 6 | 72 ± 6 | NS |
| Gender: no. | | | | |
| Male | 1226 | 1086 | 140 | NS |
| Female | 1366 | 1215 | 151 | |
| Extent of resection: no. | | | | |
| Distal | 490 | 450 | 40 | 0.03 |
| Pancreaticoduodenectomy | 2102 | 1851 | 251 | |
| No. of secondary diagnosis | | | | |
| 0 | 789 | 701 | 88 | NS |
| 1 | 1018 | 906 | 112 | |
| 2 | 586 | 519 | 67 | |
| 3 | 179 | 157 | 22 | |
| 4 | 19 | 17 | 2 | |
| 5 | 1 | 1 | 0 | |
| Secondary diagnosis | | | | |
| Diabetes | 629 | 556 | 73 | NS |
| Hypertension | 658 | 561 | 97 | 0.001 |
| Vascular | 607 | 562 | 45 | 0.001 |
| Renal | 127 | 119 | 8 | NS |
| Cardiac | 787 | 690 | 97 | NS |

NS indicates not significant.

**TABLE 2.** Demographics of Patients Subjected to Hepatic Resection for Cancer

| | Total | Low Volume | High Volume | *P* |
|---|---|---|---|---|
| No. of patients | 3734 | 3260 | 4474 | |
| No. of hospitals | 1284 | 1272 | 12 | |
| Age: mean ± standard deviation | 72 ± 6 | 71 ± 6 | 72 ± 6 | NS |
| Gender: no. | | | | |
| Male | 1893 | 1625 | 268 | 0.01 |
| Female | 1841 | 1635 | 206 | |
| Extent of resection: no. | | | | |
| <Lobectomy | 2729 | 2387 | 342 | NS |
| Lobectomy or more | 1005 | 873 | 132 | |
| No. of secondary diagnosis | | | | |
| 0 | 1283 | 1113 | 170 | NS |
| 1 | 1454 | 1275 | 179 | |
| 2 | 772 | 673 | 99 | |
| 3 | 200 | 177 | 23 | |
| 4 | 25 | 22 | 3 | |
| Secondary diagnosis | | | | |
| Diabetes | 496 | 434 | 62 | NS |
| Hypertension | 989 | 860 | 129 | |
| Vascular | 917 | 799 | 118 | |
| Renal | 179 | 156 | 23 | |
| Cardiac | 1117 | 991 | 126 | |
| Tumor type | | | | |
| Primary | 1062 | 917 | 145 | NS |
| Metastatic | 2817 | 2343 | 474 | |

NS indicates not significant.

24%). For hepatectomies, there was a slightly higher percentage of male patients at high-volume centers (57% vs 50%). Data for 1995 was nearly identical to that for 1996 (data not shown).

For both hepatic and pancreas data when comparing the number of comorbidities with high- and low-volume hospitals, the resulting chi-square is not statistically significant (*P* values 0.5361 and 0.7516, respectively).

For patients undergoing liver resections at high-volume centers, 145 of the 474 (31%) resections were performed for primary malignancies of the liver and biliary tract, whereas 329 (69%) were performed for metastatic disease. At low-volume centers, 917 (29%) of the 3260 resections were performed for primary malignancies, whereas 2343 (71%) were performed for metastatic disease.

## Analysis of Survival

### Analysis of Overall Survival

Figures 1 and 2 are the Kaplan-Meier curves depicting overall survival for patients subjected to pancreatectomy or hepatectomy, respectively. There was a significant survival advantage for patients to have had their surgery at a high-volume center.

Multivariate analysis (Table 3) confirms that hospital volume is an independent predictor of outcome for both pancreatic and liver surgery. Female gender was predictive of favorable outcome, whereas advanced age and renal disease were poor prognostic indicators.

### Analysis of Perioperative Mortality

Hospital volume was significantly correlated to perioperative mortality. For pancreatic resection, 173 of 2301 patients treated at low-volume centers died during the perioperative period for an operative mortality rate of 8%. In high-volume centers, 6 of 291 patients died for an operative mortality rate of 2% ($P = 0.001$). The relative risk of dying perioperatively in a low-volume center was 3.5.

For liver resections, 265 of 3037 patients treated at a low-volume center died perioperatively for an operative mortality rate of 9%. In high-volume centers, 21 of 474 patients died for an operative mortality rate of 4% ($P = 0.01$). The relative risk of surgery at a low-volume center was 1.8.

Male gender, advanced age, pulmonary disease, renal disease, and cardiac disease were also independent predictors of perioperative mortality.

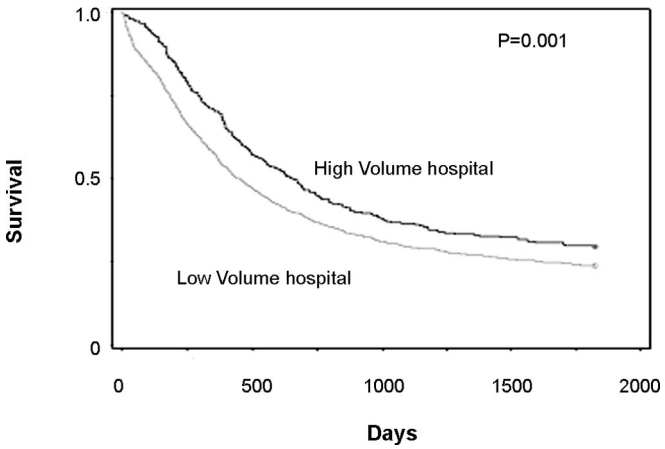


**FIGURE 1.** Survival of patients subjected to pancreatic resection for cancer.

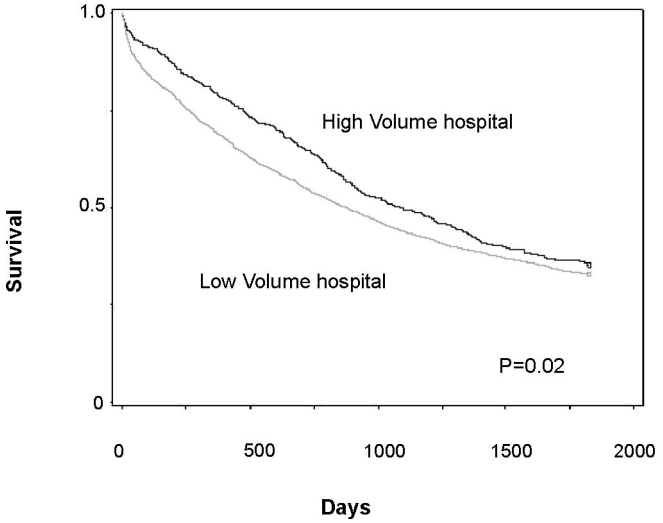


**FIGURE 2.** Survival of patients subjected to hepatic resection for cancer.

### Analysis of Long-Term Mortality Eliminating Perioperative Deaths

Figures 3 and 4 are the Kaplan-Meier curves depicting overall survival after perioperative deaths were removed. Hospital volume remains a significant predictor of long-term survival for pancreatic resections both in univariate and in multivariate analysis. For hepatic resections, hospital volume loses its significance, indicating that in this group, the major effect of volume is on the perioperative outcome.

## DISCUSSION

A number of studies have correlated perioperative outcome to hospital volume for general surgical,[16,18] vascu-

**TABLE 3.** Multivariate Analysis of Predictors of Outcome After Pancreatic or Liver Resection*

| | Pancreas | | Liver | |
|---|---|---|---|---|
| | Relative Risk | *P* | Relative Risk | *P* |
| Surgical volume | 1.3 | 0.001 | 1.2 | 0.02 |
| Gender | 0.6 | <0.001 | 0.6 | <0.001 |
| Age (10 yr) | 1.008 | 0.04 | 1.008 | 0.005 |
| Renal | 1.8 | <0.001 | 1.9 | <0.001 |
| Hypertension | 0.9 | 0.01 | 0.8 | <0.001 |
| Pulmonary | 1.2 | 0.001 | 1.1 | NS |
| Cardiac | 1.1 | NS | 1.2 | 0.002 |
| Diabetes | 1.1 | NS | 1.1 | NS |
| Extent of procedure | 1.0 | NS | 1.0 | NS |

*Covariates included hospital surgical volume, gender, age, extent of procedure, and comorbidities. Age was entered as a continuous variable.
NS indicates not significant.

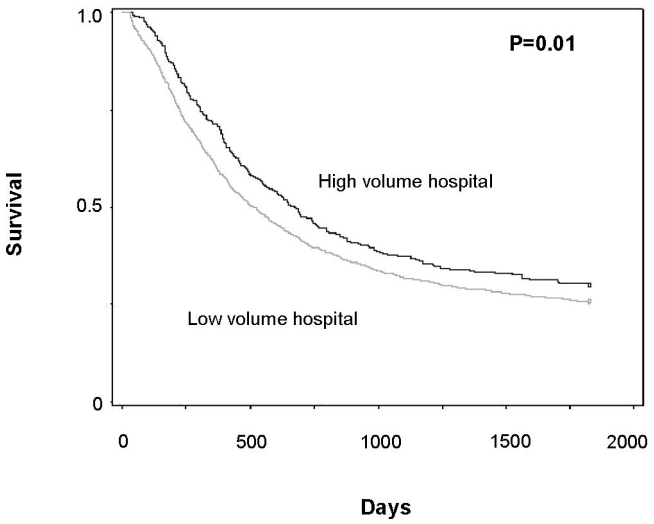


**FIGURE 3.** Long-term survival of patients who survived the perioperative period (<30 days) after pancreatic resection for cancer.

lar,[15,18] cardiac,[13,14] ophthalmic,[21] and orthopedic procedures.[22] The data for pancreatectomy and hepatectomy have been particularly convincing. Gordon and his colleagues found that pancreatectomy at a high-volume center improved outcome as measured by perioperative mortality (2% vs 14%), as well as length of hospital stay (23 vs 27 days) and cost ($26 million vs $31 million).[7] This was confirmed by Begg and his colleagues using data from the New York State registry.[9] Choti[10] and Glasgow,[11] using the state registries in Maryland and in California, respectively, found a similar association of decreased perioperative mortality with high hospital volume for patients subjected to liver resections. In the current study, we confirmed a relationship of perioperative outcome with surgical volume for both pancreatectomies and for hepatectomies using a large national database. In addition, the current study demonstrates, through long-term follow up, that this survival advantage is not lost after the perioperative period.

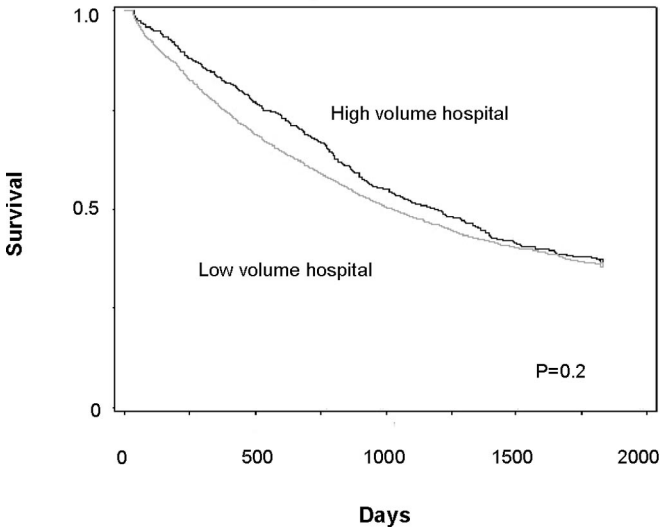


**FIGURE 4.** Long-term survival of patients who survived the perioperative period (<30 days) after liver resection for cancer.

The database used in this study is the National Medicare database. Because it is related to reimbursement for surgical intervention, all patients over age 65 with the diseases of interest are therefore accurately captured. Because pancreatic cancer and metastatic colorectal cancer are generally diseases of the elderly, this analysis includes a representative sampling of patients with these diseases. Whether the conclusions generated can be extrapolated to the minority of young patients with these diseases cannot be fully determined by the current analysis.

A few studies have also attempted to examine the influence of hospital volume on long-term outcome after treatment of other cancers. Roohan and colleagues examined 47,890 breast cancer operations in New York State performed between 1984 and 1989.[23] Five-year survival was directly correlated to hospital volume. Schrag and her colleagues performed a similar analysis of long-term outcome after surgery for colon cancer.[24] They examined 27,986 patients identified through the Surveillance, Epidemiology and End Results (SEER) database. Hospital volume was associated with a small but clear improvement in outcome that was not explained simply by a difference in use of postoperative chemotherapy. Bach and his colleagues examined 2118 patients subjected to lung resection for cancer and also found a 5-year survival rate of 44% for those treated in a high-volume hospital rather than 33% for those treated at low-volume centers ($P < 0.001$).[25] In this study, they also found an improved perioperative outcome for those treated at a high-volume center in terms of length of stay, complications, and mortality.

A single study had attempted to analyze the influence of hospital volume on late survival after pancreatectomy.[26] In this study, the authors examined the 3-year survival of 7229 patients subjected to a pancreaticoduodenectomy for malignant or benign disease. Patients who had their operation at a high-volume center had improved 3-year survival. In the current study, we expand on these previous observations by examining a more homogenous group that includes only patients with cancer. Follow up is also significantly longer with a minimum of 5-year follow up. The results confirm that this survival advantage associated with cancer surgery at a high-volume center persists beyond 3 years. These results would therefore provide additional support for regionalization of complex surgical procedures for cancer.

It is noteworthy that only 10 centers nationally could be considered a high-volume center for pancreatic resection and 12 centers for resection of hepatic colorectal metastases. Of the 1091 low-volume centers for pancreatic resection, an average of one pancreatic resection was performed per year for patients over age 65. Similarly, for the 1272 low-volume centers for resection of metastatic colorectal cancer to the liver, only one case was performed per year. Thus, referring these rarely performed complex procedures to a high-volume center would not result in an unreasonable financial loss for

these low-volume centers or their surgeons while improving the short- and long-term outcome for the patients.

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# Discussions

DR. DAVID M. NAGORNEY (ROCHESTER, MINNESOTA): The report, by Dr. Fong and colleagues, assessing long-term survival of patients after pancreatic and hepatic resection from low-volume and high-volume centers collected from the National Medicare database, provides further confirmation for the emerging data supporting the expected efficacy afforded by experience. I was struck by several aspects of this study:

1. The few "high-volume" centers within the database, even though your definition of "high-volume" was rather limited, that is, only 2 resections per month.
2. The disparity of center impact on the long-term survival after hepatic resections.
3. The notable absence of analyzing for chronic liver disease as a comorbidity for hepatic resections.

My questions are the following:

1. You conclude that these data provide additional support for regionalization of complex surgical procedures for cancer. Is the power of these findings based on your definition of "high-volume" coupled with others strong enough now to warrant that recommendation? I'm sure that the "high-volume" centers could handle the patient load for complex procedures given your definition but perhaps by stratification of some pancreatic and hepatic resections based on other risk factors such as those brought out earlier at this meeting or fixing the system to improve outcomes of low volume centers would provide efficacious alternatives.
2. Operation is only 1 point of patient management. Much management occurs with cancer patients between operation and date of last follow up. Could you speculate what that interval management may have had on the differences in survival? Is such data retrievable from the Medicare database?
3. Underlying liver disease is predictive of outcome for HCC. Could this be the reason why there was a late convergence in the tails of the survival curves between the centers for hepatic resection?
4. Finally, was survival censored for late noncancer related deaths?

I enjoyed your presentation and appreciated the opportunity for comment.

DR. YUMAN FONG (NEW YORK, NEW YORK): First of all in regards to your comment about how few liver or pancreatic operations there were, I like to emphasize that this is the National Medicare Database and therefore it only represents data from 1 single payer. And these are all patients that are over the age 65. So depending on the hospital mix of payers and patients, there could be 4 or 5 times higher numbers of actual surgeries in terms of pancreatectomies or liver resections that are performed. At our hospital, for example, about one-third of the patients are Medicare patients, and therefore our numbers would be increased by threefold, depending on how we looked at the data. So I think there are many more liver and pancreatic operations done out there. Nevertheless, it was surprising to me how few centers we could really consider high volume centers when you looked at number of cases that are done at the particular centers.

Your second question asked whether high volume centers should be recommended as the only place to have cancer surgery. From a perioperative mortality standpoint, the data is clearly yes. The data is only starting to merge about the long-term outcome. I think it is still early. This will be the fifth paper in the literature that looks at long-term follow-up. As that literature matures I think that it will become clear which operations it will make sense to have done at a major center. I think the public has already taken the perioperative data in hand. It is very uncommon for me to see a patient who hasn't looked around to see how many cases are done in each hospital.

Your next question was about how much of an effect the multidisciplinary nature of cancer care at the centers had on the outcome. For certain cancers it should make a big difference. That is why in Debra Shragg's paper looking at colon cancer and long-term outcome from cancer surgery, she actually factored in the use of chemotherapy after surgery and what percentage at low and high volume centers were actually treated with adjuvant therapy.

For the cancers that we are talking about here I think that it would be less of an issue. For example, for pancreatic cancer, even though we give adjuvant therapy to a lot of folks I am not yet convinced that it makes a huge impact on long-term outcome. And certainly for primary hepatocellular carcinoma or for primary biliary cancers of the liver there is no good adjuvant therapy that we are currently giving to people. However, I agree with you that when we analyze long-term outcomes according to institutional volume, we should certainly look at adjuvant therapy and interventional therapy as part of a risk factor for poor or good outcome.

As for noncancer deaths in terms of censoring, we did not separate noncancer versus cancer deaths. This is just all deaths. But there was a very good follow-up. All patients are followed at least 5 years. So these data report actual mortality in this patient population.

DR. ANDREW L. WARSHAW (BOSTON, MASSACHUSETTS): I am going to confine my questions to the pancreas portion because that is all I know about. My questions are to try to get at the mechanism of the differences that you have shown us.

Are you assuming or could it be that the reason for the difference in the curves is that the surgeon did a better operation, a more complete dissection, or something in the surgical procedure? Or is it better patient selection? Are the high volume centers better at picking out the patient who is most likely to have negative resection margins and therefore who is going to have a better outcome from the get-go?

You did point out there was a statistically significant difference between cancers in the head vs. the body and tail in the series. A Whipple operation is more likely to get negative margins and the chance for a cure than with a distal resection in which the cancer is more likely to be carved out with positive margins. If there are more distal resections and fewer Whipples at low volume hospitals, can this factor account for the observed differences in survival curves?

Your most interesting and inexplicable observation is that, once you have wiped out the initial perioperative mortality, your curves are divergent right from the start and remain parallel. So it is neither perioperative death nor simply late deaths from recurrent cancer that can explain the difference at 3 to 5 years. How do you account for this?

DR. YUMAN FONG (NEW YORK, NEW YORK): If Dr. Polk wants a short answer, it would be, "I don't know." Whether it is patient selection or whether it is technical expertise at the major centers that is responsible for the results is very hard to sort out from a national database.

One way that we can try to sort that out in other studies is to look at how many imaging studies have been done or look at margins on the final pathology. But that data is not available in terms of correlating to our current study set. However, those would be fascinating things to look at.

PROF. J. HANS JEEKEL (ROTTERDAM, NETHERLANDS): That was an excellent paper with a large number of patients, confirming maybe that adjuvant treatment may have been given more frequently in the centers with high volume. But I don't think that would make any difference in pancreatic cancer, because it is now well proven that radiotherapy and 5 FU or other treatment combinations of chemotherapy and radiotherapy are not effective. And that is what too often is still given.

Isn't it an amazing thing that we all demonstrate that the survival is lower in small volume hospitals and still there is no implementation of this result. You didn't mention many studies from Europe, where it has been demonstrated also that operative mortality is lower in high volume centers.

Of course there are no prospective randomized blinded studies on this subject. It is not Level I evidence but still we should take it as evidence. Don't you think there is now proof for low operative mortality and higher survival in high volume centers? And isn't it easy then to do something for the patient just to change to high volume centers? Then you improve survival and you lower your operative mortality. What would you like more? It seems so easy to do. How are you going to implement it?

Dr. Yuman Fong (New York, New York): I totally agree with your comments about the fact that there is ample proof that perioperative outcome is better for complex operations at major centers and therefore on that basis alone patients should be operated on at high volume centers for the high-end kind of surgery. What I am not yet 100% convinced of is which cancers it will change in terms of long-term outcome for the patient. But I agree with you, most of the major operations should be done at high volume centers. How to implement that, I leave it to our leadership and hope that by contributing data that we all help in bringing that about.

Dr. John L. Cameron (Baltimore, Maryland): Dr. Fong, your very nice study, as well as dozens of other studies on volume and outcome, support regionalization or centralization of certain diseases or operative procedures. In the middle of the 1980s, beginning in 1983, at Hopkins we became interested in the Whipple procedure for a variety of pancreatic diseases. At that time we did only 20% of the Whipples in the state of Maryland. Overall at that time statewide mortality for the operation was approximately 20%. By 1994, 10 or 11 years later, we did over 60% of the Whipples in the state, and the mortality had dropped to 5%. To my knowledge, this is the first demonstration that I am aware of that regionalization in an area as big as a state could result in saving lives. I believe we now do over 80% of the Whipples in the state of Maryland. So regionalization can occur and can work. I wonder if you have any information on how many states, including your own, where regionalization has occurred. Memorial Sloan-Kettering and The Johns Hopkins Hospital published outcome data about the same data, and I think that spurred regionalization in the state of Maryland. Has it in the state of New York?

Dr. Yuman Fong (New York, New York): I actually do not have the data on what is happening in the state of New York or around the nation. But clearly the work that you and your colleagues have done at Hopkins has been pioneering work that has changed many people's minds about having major surgery at a high volume center.

I think the public, though, is acting on all these data. It is very common that folks will bring an entire sheet of potential surgeons for their operation and what their caseload is and see me in the office with this list in their hand. And I think the public will push for this.

But I think from the surgery leadership standpoint, we need to push for this, also. And it is a matter of how we gather all this data and make it happen.

Dr. Hiram C. Polk, Jr. (Louisville, Kentucky): I made the point yesterday there is at least $5000 greater profit for every insurer for health care in America when a patient is referred to a physician with special skills in a given disease and/or operation. That is going to drive some changes, too, that is the profitability for the insurer.

Dr. Eric Munoz (Newark, New Jersey): Some important things have been said here. One thing that I think that a lot of people are agreeing on, for certain operations, which are unfortunately a small number of operations in the United States, volume is related to what happens. So there is no disagreement with that, although we disagree once you get into other aspects in the clinical world.

But more importantly is for the 25 million operations done a year in America can you cut volume/outcome in any way that makes any sense? First of all, do we have databases that exist that allow us to start looking at some of those parameters? I would say we need to study this more. It is real hard for many common operations, ie colectomy, prostatectomy, hip replacement, how do we actually do that? Can we do it?

The other thing that has been mentioned is once you get into the political world, the Congress of the United States and the administration determines the Medicare payment, which everyone else follows, and in fact it then gets very complicated relative to access to surgical care. What if you live in Tennessee, or what if you live in North Dakota, and access gets to be an important problem and an issue. And that is going to be something that gets thrown up in our faces.

Dr. John P. Roberts (San Francisco, California): How did you come up with the number of 25? Did you look at your data in terms of relative risk versus center volume to see if there was a break point?

Dr. Yuman Fong (New York, New York): We were actually trying to see if we took 10% of the operations, what the numbers would look like. We wanted an even number. There was no exact science. There was no major break at that point. It actually turned out that it gave us 1% of institutions and 10% of the operations and it was an even number.

Dr. Frank R. Lewis (Philadelphia, Pennsylvania): You plotted your survival data using a linear scale for the number of cases. Although that is a time-honored method of doing it, it is actually not a great method because it is

impossible on that sort of a graph to interpret the yearly survival rates or changes that might occur.

The fact is your data would reveal a good deal more about the yearly mortality rates in each of these groups if it were replotted using a logarithmic scale on the Y axis. I wonder if you have done this yourself in order to assess changes in survival rates, and particularly the long-term changes in survival rate as a function of where the surgery was done.

DR. YUMAN FONG (NEW YORK, NEW YORK): We have not done that yet. It is a great suggestion and we will certainly do that.

For pancreatectomies, for example, at 1 year there is a 13% difference in survival and at 2 years there is a 6% difference. That 6% is maintained throughout the rest of the curve. But we could certainly plot it out on a logarithmic scale and see that in a much more apparent fashion.